§5-4 Momentum + Newton's Laws

momentum - the product of an object's velocity and its mass.

$$\vec{p} = m\vec{v}$$

Where $\vec{p}$ is the momentum (kg m/s)

m is the mass (kg)

$\vec{v}$ is the velocity (m/s)

MP|197

$m = 0.300\,kg$

$\vec{v} = 5.55\,m/s\,[N]$

$\vec{p} = ?$

$\vec{p} = m\vec{v}$

$\vec{p} = (0.300\,kg)(5.55\,m/s\,[N])$

$\vec{p} = 1.665\,kg \cdot m/s\,[N]$

$\vec{p} \doteq 1.66\,kg \cdot m/s\,[N]$

Impulse - the product of the force acting on an object and the duration the force acts.

$$\vec{J} = \vec{F}\Delta t$$

where $\vec{J}$ is the impulse ($N \cdot s$)

$\vec{F}$ is the force (N)

Δt is the duration the force acts over (s)

MP 199

$\vec{F} = 5.25 \times 10^3 N [W]$

$\Delta t = 5.45 \times 10^{-4} s$

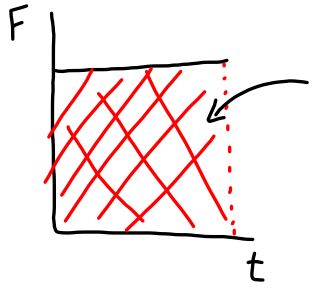
$\vec{J} = ?$

$$\vec{J} = \vec{F}\Delta t$$

$$\vec{J} = (5.25 \times 10^3 N[W])(5.45 \times 10^{-4} s)$$

$$\vec{J} \doteq 2.86 Ns [W]$$

Consider a constant force acting on an object:



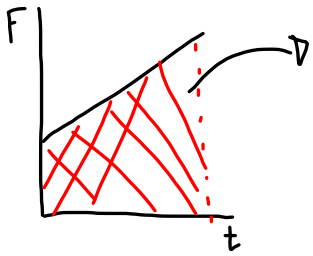
Area of Rectangle = $l \times w$

Area = $F\Delta t$

But $\vec{J} = F\Delta t$

What if the force is not constant?

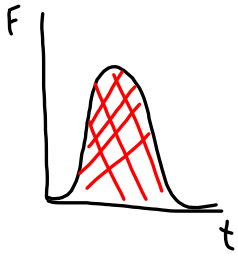
So Area $(F \cdot t)$ = Impulse



Area of trapezoid = $\frac{1}{2}(h_1 + h_2)b$

Area = $\frac{1}{2}(F_1 + F_2)\Delta t$

Area = $F_{ave}\Delta t$



① Count squares.

② Use Calculus

③ Use technology (Logger Pro)

Impulse-Momentum Theorem

Recall Newton's Second Law:

$$\vec{F}_{net} = m\vec{a}$$

$$\vec{F}_{net} = m\left(\frac{\Delta \vec{v}}{\Delta t}\right)$$

$$\vec{F}_{net}\,\Delta t = m\,\Delta \vec{v} \quad \leftarrow \Delta \vec{p}$$

$$\vec{F}_{net}\,\Delta t = m(\vec{v}_2 - \vec{v}_1)$$

$$\vec{F}_{net}\,\Delta t = m\vec{v}_2 - m\vec{v}_1$$

$$\vec{F}_{net}\,\Delta t = \vec{p}_2 - \vec{p}_1$$

the concept!

$$\vec{J} = \Delta \vec{p}$$

← Impulse-Momentum Theorem.

more practical

$$\vec{F}_{net}\,\Delta t = m\Delta \vec{v}$$

MP|201

$m = 0.060\,kg$

$v_1 = +48\,m/s$

$v_2 = -35\,m/s$

(+ ⇒ towards wall)

(- ⇒ away fr. wall)

$\Delta t = 25\,ms$

a) $\vec{J} = ?$

b) $\vec{F}$(wall on ball) = ?

Using the impulse momentum theorem:

$$\vec{J} = \Delta\vec{p}$$

$$\vec{J} = m\Delta\vec{v}$$

$$\vec{J} = m(\vec{v}_2 - \vec{v}_1)$$

$$J = 0.060\,kg\,(-35\,m/s - (+48\,m/s))$$

$$J = 0.060\,kg\,(-83\,m/s)$$

$$J = -5.0\,kg\cdot m/s$$

$$\vec{J} = 5.0\,kg\cdot m/s\ [\text{away from the wall}]$$

$N\cdot s = kg\cdot\frac{m}{s^2}\cdot s = kg\cdot m/s$

b) $\vec{J} = \vec{F}\Delta t$

$$\vec{F} = \frac{\vec{J}}{\Delta t}$$

$$\vec{F} = \frac{5.0\,kg\cdot m/s\ [\text{away fr. wall}]}{25\times10^{-3}\,s}$$

$$\vec{F} = 2.0\times10^{2}\,N\ [\text{away from the wall}]$$

(the force of the wall on the ball)

What is the force of the ball on the wall?

$2.0\times10^{2}\,N$ [towards the wall]

(Newton's 3rd Law)

To Do:

① PP|197

② PP|200

③ PP|203